Internal Flow Environment of Swirl Injectors

Project Number: 93-19

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Purpose

Study the internal flow environment in the central posts of tangential-entry, swirl coaxial injector elements typical of those used in liquid propellant rockets.

Background

Liquid propellant rockets typically mix their fuel and oxidizer in the combustion chamber. The performance of the rocket is then highly dependent on the quality of this mixing. An injector must therefore provide a sufficiently uniform distribution of fuel and oxidizer at the head end of the combustion chamber. For propellants with a large variation between the fuel and oxidizer densities as in the case of liquid oxygen (lox) and gaseous hydrogen, two types of injectors are commonly used:

- Shear coaxial—a large number of injection elements in which the high density fluid flows through a central tube surrounded by an annulus of high velocity gas which breaks up and disperses the liquid stream; and

- Swirl coaxial—elements are similar in appearance to shear elements, except one or more of the propellants are given a tangential velocity to aid the mixing of the propellants.

It has been demonstrated that high combustion efficiencies can be obtained from shear coaxial elements. However, a large number of elements are required and these elements are susceptible to injection-coupled combustion instability. Swirl coaxial injector elements may offer an advantage in both of these areas which could result in decreased development and production costs of these types of engines.

Approach

In order to understand the effect of lox post-geometry on the stability and performance of a rocket, the internal flowfield of the post must be known. The approach taken in this study was to construct acrylic models of lox posts and then test using water as a lox simulant. The posts were constructed of acrylic, and water was used as the liquid simulant flowing into ambient backpressure air (fig. 3). Measurements were made of the axial pressure distribution, the shape of the air core formed in the post, the velocity profile in the liquid film, and the spatial mass flow distribution of the spray cone. Swirler caps were tested using both a nine-hole and a three-slot configuration. The baseline post was 0.3 inch in diameter and had a length of 5.5 inches. Posts with a reduction or expansion at the exit were also tested. The air core extended the entire length of the post in all cases. The thickness of the film was indicative of the effectiveness of the swirler inlet design. A thin liquid film always corresponded to a wide spray cone. A one-dimensional, variable flow area model of the flow was developed to predict the steady-state flowfield and to provide insight into postflow effects on combustion stability (fig. 4).

Accomplishments

Approximately 30 percent of the final report has been completed.

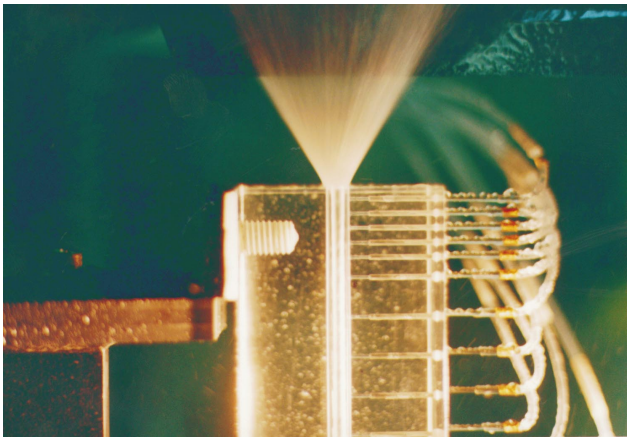

FIGURE 3.—Photograph of post exit region.

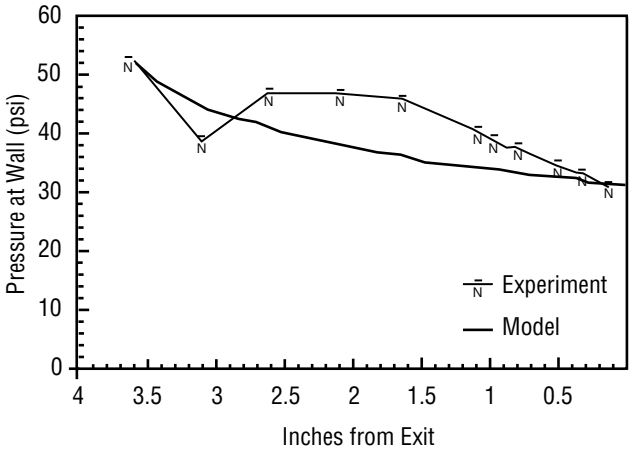

FIGURE 4.—Post wall pressure.

Planned Future Work

Complete final report

Funding Summary ($k)

	FY97	FY98	Total
Authorized:	75	45	120
Obligated:	75	45	120

Status of Investigation

Project approval—October 2, 1992

Estimated completion—November 1, 1997

Project complete pending final report (currently at 30 percent completion).